GEAR ENGINEERING DATA

Stock Spur Gear Drive Selection

When designing a stock gear drive using the horsepower tables in this catalog, the following steps must be taken:

I. Find out these five necessary things:

a. Exact center distance in inches
b. Ratio and speeds
c. Service factor (from page G-84)
d. Actual horsepower
e. Bore sizes of both gears

II. Determine design horsepower using formula:

$$DHP = HP \times SF$$

Where: DHP = Design horsepower
HP = Actual horsepower
SF = Service factor (from page G-84)

III. Determine pitch diameters using the formulas:

$$PD_1 = \frac{CD \times 2}{Ratio + 1}$$

$$PD_2 = PD_1 \times Ratio$$

Where: PD_1 = Pitch diameter of pinion (small gear)
PD_2 = Pitch diameter of gear (large gear)
CD = Center distance

IV. Check the center distance:

$$CD = \frac{PD_1 + PD_2}{2}$$

V. Select pitch from horsepower tables on pages G-25 — G-27.

VI. Check selected pitch for necessary pitch diameters.

VII. Check horsepower capacity of large gear.

VIII. Check maximum bore capacity of selected gears.

Spur Gear Drive Selection II (Other Than Stock)

When designing a gear drive when horsepower and speeds exceed the stock gear tables on pages G-25 – G-27, the following steps must be taken:

I. We must obtain all of the following data:

a. Exact center distance in inches
b. Ratio and speeds
c. Service factor (from page G-84)
d. Actual horsepower
e. Bore sizes of both gears

II. We must obtain all of the following data:

$$DHP = HP \times SF$$

Where: DHP = Design horsepower
HP = Actual horsepower
SF = Service factor (from page G-84)

III. Determine pitch diameters using the formulas:

$$PD_1 = \frac{CD \times 2}{Ratio + 1}$$

$$PD_2 = PD_1 \times Ratio$$

Where: PD_1 = Pitch diameter of pinion (small gear)
PD_2 = Pitch diameter of gear (large gear)
CD = Center distance

IV. Determine velocity using the formula:

$$V = .262 \times PD \times RPM$$

Where: V = Velocity in feet per minute @ pitch line
PD = Pitch diameter
RPM = Revolutions per minute of either gear*

V. Determine approximate pitch using the formula:

$$DP = \sqrt{\frac{3.1416 \times S \times 3 \times V \times .25}{DHP \times 27.5\ (1200 + V)}}$$

Where: DP = Diametral Pitch
S = Safe Static Stress per Square Inch of material (see table one, page G-84)
V = Velocity in FPM
DHP = Design Horsepower

Note: To round off answers, go to the nearest DP (standard DP's larger than 3 DP are: 1 DP, 1 1/4 DP, 1 1/2 DP, 1 3/4 DP, 2 DP, 2 1/2 DP)

VI. Determine number of teeth on both gears:

$$N = PD \times DP$$

Where: N = Number of teeth
PD = Pitch diameter of gear
DP = Diametral pitch of gear

VII. Determine face width:

$$F = \frac{DP\left(\frac{DHP \times 33{,}000}{V}\right)}{SY\left(\frac{600}{600 + V}\right)}$$

Where: F = Face Width
DP = Diametral Pitch
V = Velocity in FPM
S = Safe Static Stress per Square Inch of material (Table 1, page G-84)
Y = Outline formula from Table 2, page G-84

Note: To round off each answer, go to the next one inch.

VIII. Check HP rating of selected pinion using the formula::

$$HP = \frac{LV}{33{,}000}$$

Where: $$L = \frac{SYF}{DP} \times \frac{600}{600 + V}$$

From horsepower formulas on page G-83.

Note: If the horsepower capacity is below the design horsepower, the following options can be taken:

a. Harden pinion (check gear HP capacity first)
b. Increase face
c. Increase pitch

* NOTE: Velocities of both gears will always be the same. When using the above formula make sure to use the proper speed (RPM) with the proper pitch diameter.

Center Distance, Pitch Diameters and Ratios of Spur Gears

I. To determine the pitch diameters of a gear set, we must find two basic things:
   a. Required ratio
   b. Required center distance

II. Knowing this, first figure out the pitch diameter of the pinion (smaller gear) using the formula:

$$PD_1 = \frac{CD \times 2}{Ratio + 1}$$

Where: PD_1 = Pitch diameter of pinion (small gear)
CD = Center distance

III. Then, find the pitch diameter of the larger gear, PD2, by using the formula:

$$PD_2 = PD_1 \times Ratio$$

Where: PD_1 = Pitch diameter of pinion (small gear)
PD_2 = Pitch diameter of gear (large gear)
CD = Center distance

IV. Then check the center distance by using the formula:

$$CD = \frac{PD_1 + PD_2}{2}$$

Where: PD_1 = Pitch diameter of pinion (small gear)
PD_2 = Pitch diameter of gear (large gear)
CD = Center distance

Horsepower Formulas

See page G-84 for tables one, two and three.

Engineering Data

Lewis formula (with Barth revision)

L = Load in pounds at pitch line

S = Safe static stress per square inch of material (see table one)

DP = Diametral Pitch

F = Face width of gear

Y = Strength factor based on Pressure Angle and Number of Teeth (See table two)

V = Velocity in feet per minute

V = .262 × PD × RPM

PD = Pitch Diameter

RPM = Revolutions Per Minute

HP = Horsepower

$$L = \frac{SYF}{DP} \times \frac{600}{600 + V}$$

Maximum allowable torque (T) that should be imposed on a gear will be the safe tooth load (L) multiplied by:

$$\frac{DP}{2} \text{ or } T = \frac{L \times PD}{2}$$

The safe Horsepower capacity of the gear (at a given RPM) can be calculated from:

$$HP = \frac{T \times RPM}{63{,}025}$$

Or directly from (L) and (V):

$$*HP = \frac{LV}{33{,}000}$$

For a known HP:

$$T = \frac{63025 \times HP}{RPM}$$

For NON-METALLIC GEARS, the modified Lewis formula shown below may be used with (S) values of 6000 PSI for phenolic laminated material.

$$L = \frac{SYF}{DP}\left(\frac{150}{200 + V} + .25\right)$$

* Apply SERVICE FACTOR (table three) for required horsepower.

Gear Standards

Table One
(S) Average values in pounds per square inch

Material	S
Steel — .40 Carbon	25000
— .20 Carbon	20000
Steel — .40 Carbon Heat Treated	35000
Cast Iron	12000
Bronze	10000
Non-Metallic	6000

Table Two
Outline factor Y for use with Diametral Pitch

Number of Teeth	14 1/2 P.A. Involute	20 P.A. Involute	Number of Teeth	14 1/2 P.A. Involute	20 P.A. Involute
10	.176	.201	26	.308	.344
11	.192	.226	28	.314	.352
12	.210	.245	30	.318	.358
13	.223	.264	35	.327	.373
14	.235	.276	40	.336	.389
15	.245	.289	45	.340	.399
16	.255	.295	50	.346	.408
17	.264	.302	60	.355	.421
18	.270	.308	70	.360	.429
19	.277	.314	80	.363	.436
20	.283	.320	90	.366	.442
21	.289	.326	100	.368	.446
22	.292	.330	150	.375	.458
23	.296	.333	200	.378	.463
24	.302	.337	RACK	.390	.484
25	.305	.340			

Table Three
Service factors
Multiply required horsepower by service factor recommended for type of service

Type of Load	Intermittent Of 3 Hours Per Day	8-10 Hours Per Day	Continuous 24 Hours Per Day
UNIFORM	0.80	1.00	1.25
LIGHT SHOCK	1.00	1.25	1.50
MEDIUM SHOCK	1.25	1.50	1.80
HEAVY SHOCK	1.50	1.80	2.00

Spur Gear Dimensional Formulas Diametral Pitch

Rules and Formulas For Spur Gear Calculations

Diametral Pitch is the number of teeth to each inch of the pitch diameter.

To Find	Having	Rule	Formula
Diametrical Pitch (DP)	Circular Pitch (CP)	Divide 3.1416 by Circular Pitch (CP)	$DP = \frac{3.1416}{CP}$
	Pitch Diameter (PD) and Number of Teeth (N)	Divide Number of Teeth (N) by Pitch Diameter (PD)	$DP = \frac{N}{PD}$
	Outside Diameter (OD) and Number of Teeth (N)	Divide Number of Teeth (N) plus 2 by Outside Diameter (OD)	$DP = \frac{N + 2}{OD}$
Pitch Diameter (PD)	Number of Teeth (N) and Diametral Pitch (DP)	Divide Number of Teeth (N) by Diametral Pitch (DP)	$PD = \frac{N}{DP}$
	Number of Teeth (N) and Outside Diameter (OD)	Divide product of Outside Diameter (OD) and Number of Teeth (N) by Number of Teeth (N) plus 2	$PD = \frac{OD \times N}{N + 2}$
	Outside Diameter (OD) and Diametral Pitch (DP)	Subtract from Outside Diameter (OD) quotient of 2 divided by Diametral Pitch (DP)	$PD = OD - (2 \div DP)$
	Addendum (a) and Number of Teeth (N)	Multiply Addendum (a) by Number of Teeth (N)	$PD = a \times N$
Outside Diameter (OD)	Number of Teeth (N) and Diametral Pitch (DP)	Divide Number of Teeth (N) plus 2 by Diametral Pitch (DP)	$OD = \frac{N + 2}{DP}$
	Pitch Diameter (PD) and Diametral Pitch (DP)	Add to Pitch Diameter (PD) quotient of 2 divided by Diametral Pitch (DP)	$OD = PD + \frac{2}{DP}$
	Pitch Diameter (PD) and Number of Teeth (N)	Divide Number of Teeth (N) plus 2 by quotient of Number of Teeth (N) divided by Pitch Diameter (PD)	$OD = \frac{N + 2}{N \div PD}$
	Number of Teeth (N) and Addendum (a)	Multiply Number of Teeth (N) plus 2 by Addendum (a)	$OD = (N + 2) \times a$
Number Of Teeth (N)	Pitch Diameter (PD) and Diametral Pitch (DP)	Multiply Pitch Diameter (PD) by Diametral Pitch (DP)	$N = PD \times DP$
	Outside Diameter (OD) and Diametral Pitch (DP)	Multiply Outside Diameter (OD) by Diametral Pitch (DP) and subtract 2	$N = (OD \times DP) - 2$
Thickness Of Tooth (t)	Diametral Pitch (DP)	Divide 1.5708 By Diametral Pitch (DP)	$t = \frac{1.5708}{DP}$
Addendum (a)	Diametral Pitch (DP)	Divide 1 by Diametral Pitch (DP)	$a = \frac{1}{DP}$
Dedendum (b)	Diametral Pitch (DP)	Divide 1.157 By Diametral Pitch (DP)	$b = \frac{1.157}{DP}$
Working Depth (hk)	Diametral Pitch (DP)	Divide 2 by Diametral Pitch (DP)	$hk = \frac{2}{DP}$
Whole Depth (ht)	Diametral Pitch (DP)	Divide 2.157 By Diametral Pitch (DP)	$ht = \frac{2.157}{DP}$
Clearance (c)	Diametral Pitch (DP)	Divide .157 By Diametral Pitch (DP)	$c = \frac{.157}{DP}$
	Thickness of Tooth (t)	Divide Thickness of Tooth (t) at Pitch Line by 10	$c = \frac{t}{10}$

Note: Rules and formulas relating to tooth depth and outside diameter apply to full-depth, equal addendum gears.

Diametral Pitch
Tooth Dimensions

Dimensions of Standard Full-depth Teeth

Diametral Pitches and Equivalent Circular Pitches

Diametral Pitch	Circular Pitch	Module	Arc thickness of Tooth on Pitch Line	Addendum	Working Depth of tooth	Dedendum of Depth of Space Below Pitch Line	Whole Depth of Tooth*
1/2	6.2832	50.8	3.1416	2.0000	4.0000	2.3142	4.3142
3/4	4.1888	33.8667	2.0944	1.3333	2.6666	1.5428	2.8761
1	3.1416	25.4	1.5708	1.0000	2.0000	1.1571	2.1571
1 1/4	2.5133	20.32	1.2566	0.8000	1.6000	0.9257	1.7257
1 1/2	2.0944	16.9333	1.0472	0.6666	1.3333	0.7714	1.4381
1 3/4	1.7952	14.5143	0.8976	0.5714	1.1429	0.6612	1.2326
2	1.5708	12.7	0.7854	0.5000	1.0000	0.5785	1.0785
2 1/4	1.3963	11.2889	0.6981	0.4444	0.8888	0.5143	0.9587
2 1/2	1.2566	10.16	0.6283	0.4000	0.8000	0.4628	0.8628
2 3/4	1.1424	9.2364	0.5712	0.3636	0.7273	0.4208	0.7844
3	1.0472	8.4667	0.5236	0.3333	0.6666	0.3857	0.7190
3 1/2	0.8976	7.2571	0.4488	0.2857	0.5714	0.3306	0.6163
4	0.7854	6.35	0.3927	0.2500	0.5000	0.2893	0.5393
5	0.6283	5.08	0.3142	0.2000	0.4000	0.2314	0.4314
6	0.5236	4.2333	0.2618	0.1666	0.3333	0.1928	0.3595
7	0.4488	3.6286	0.2244	0.1429	0.2857	0.1653	0.3081
8	0.3927	3.175	0.1963	0.1250	0.2500	0.1446	0.2696
9	0.3491	2.8222	0.1745	0.1111	0.2222	0.1286	0.2397
10	0.3142	2.54	0.1571	0.1000	0.2000	0.1157	0.2157
11	0.2856	2.3091	0.1428	0.0909	0.1818	0.1052	0.1961
12	0.2618	2.1167	0.1309	0.0833	0.1666	0.0964	0.1798
13	0.2417	1.9538	0.1208	0.0769	0.1538	0.0890	0.1659
14	0.2244	1.8143	0.1122	0.0714	0.1429	0.0826	0.1541
15	0.2094	1.6933	0.1047	0.0666	0.1333	0.0771	0.1438
16	0.1963	1.5875	0.0982	0.0625	0.1250	0.0723	0.1348
17	0.1848	1.4941	0.0924	0.0588	0.1176	0.0681	0.1269
18	0.1745	1.4111	0.0873	0.0555	0.1111	0.0643	0.1198
19	0.1653	1.3368	0.0827	0.0526	0.1053	0.0609	0.1135
20	0.1571	1.27	0.0785	0.0500	0.1000	0.0579	0.1079
22	0.1428	1.1545	0.0714	0.0455	0.0909	0.0526	0.0980
24	0.1309	1.0583	0.0654	0.0417	0.0833	0.0482	0.0898
26	0.1208	0.9769	0.0604	0.0385	0.0769	0.0445	0.0829
28	0.1122	0.9071	0.0561	0.0357	0.0714	0.0413	0.0770
30	0.1047	0.8467	0.0524	0.0333	0.0666	0.0386	0.0719
32	0.0982	0.7938	0.0491	0.0312	0.0625	0.0362	0.0674
34	0.0924	0.7471	0.0462	0.0294	0.0588	0.0340	0.0634
36	0.0873	0.7056	0.0436	0.0278	0.0555	0.0321	0.0599
38	0.0827	0.6684	0.0413	0.0263	0.0526	0.0304	0.0568
40	0.0785	0.635	0.0393	0.0250	0.0500	0.0289	0.0539

*NOTE: Dimensions listed are for HOB CUT TEETH ONLY. Shaper cut teeth may be slightly larger. Consult factory for exact measurement.

Spur Gear Dimensional Formulas Circular Pitch

Rules and Formulas For Spur Gear Calculations

Circular Pitch is the distance from the center of one tooth to the center of the next tooth, measured along the pitch circle.

To Find	Having	Rule	Formula
Circular Pitch (CP)	Diametral Pitch (DP)	Divide 3.1416 by Diametral Pitch (DP)	$CP = \frac{3.1416}{DP}$
	Pitch Diameter (PD) and Number of Teeth (N)	Divide Pitch Diameter (PD) by product of .3183 and Number of Teeth (N)	$CP = \frac{PD}{.3183 \times N}$
	Outside Diameter (OD) and Number of Teeth (N)	Divide Outside Diameter (OD) by product of .3183 and Number of Teeth (N) plus 2	$CP = \frac{OD}{.3183 (N + 2)}$
Pitch Diameter (PD)	Number of Teeth (N) and Circular Pitch (CP)	The continued product of Number of Teeth (N), Circular Pitch (CP) and .3183	PD = N x CP x .3183
	Number of Teeth (N) and Outside Diameter (OD)	Divide product of Number of Teeth (N) and Outside Diameter (OD) by Number of Teeth (N) plus 2	$PD = \frac{N \times OD}{N + 2}$
	Outside Diameter (OD) and Circular Pitch (CP)	Subtract from Outside Diameter (OD) product of Circular Pitch (CP) and .6366	PD = OD – (CP x .6366)
	Addendum (a) and Number of Teeth (N)	Multiply Number of Teeth (N) by Addendum (a)	PD = N x a
Outside Diameter (OD)	Number of Teeth (N) and Circular Pitch (CP)	The continued product of Number of Teeth (N) plus 2, Circular Pitch (CP) and .3183	OD = (N + 2) CP x .3183
	Pitch Diameter (PD) and Circular Pitch (CP)	Add to Pitch Diameter (PD) product of Circular Pitch (CP) and .6366	OD = PD+ (CP x .3183)
	Number of Teeth (N) and Addendum (a)	Multiply Addendum (a) by Number of Teeth (N) plus 2	D = a x (N + 2)
Number of Teeth (N)	Pitch Diameter (PD) and Circular Pitch (CP)	Divide product of Pitch Diameter (PD) and 3.1416 by Circular Pitch (CP)	$N = \frac{PD \times 3.1416}{CP}$
Thickness of Tooth (t)	Circular Pitch (CP)	One-half Circular Pitch (CP)	$t = \frac{CP}{2}$
Addendum (a)	Circular Pitch (CP)	Multiply Circular Pitch (CP) by .3183	a = CP × .3183
Dedendum (b)	Circular Pitch (CP)	Multiply Circular Pitch (CP) by .3683	b = CP × .3683
Working Depth (hk)	Circular Pitch (CP)	Multiply Circular Pitch (CP) by .6366	hk = CP × .6366
Whole Depth (ht)	Circular Pitch (CP)	Multiply Circular Pitch (CP) by .6866	ht = CP × .6366
Clearance (c)	Circular Pitch (CP)	Multiply Circular Pitch (CP) by .05	c = CP × .05
	Thickness of Tooth (t)	One-Tenth the Thickness of Tooth (t) at Pitch Line	$c = \frac{t}{10}$

Note: Rules and formulas relating to tooth depth and outside diameter apply to full-depth, equal addendum gears.

Circular Pitch Gears Made-To-Order Only

Circular Pitch
Tooth Dimensions

Dimensions of Standard Full-depth Teeth

Circular Pitches and Equivalent Diametral Pitches

Diametral Pitch	Diametral Pitch	Module	Arc thickness of Tooth on Pitch Line	Addendum	Working Depth of tooth	Dedendum of Depth of Space Below Pitch Line	Whole Depth of Tooth*
4	0.7854	32.3402	2.0000	1.2732	2.5464	1.4732	2.7464
3 1/2	0.8976	28.2581	1.7500	1.1140	2.2281	1.2890	2.4031
3	1.0472	24.2552	1.5000	0.9549	1.9098	1.1049	2.0598
23/4	1.1424	22.2339	1.3750	0.8753	1.7506	1.0128	1.8881
2 1/2	1.2566	20.2117	1.2500	0.7957	1.5915	0.9207	1.7165
2 1/4	1.3963	18.1913	1.1250	0.7162	1.4323	0.8287	1.5448
2	1.5708	16.1701	1.0000	0.6366	1.2732	0.7366	1.3732
1 7/8	1.6755	15.1595	0.9375	0.5968	1.1937	0.6906	1.2874
1 3/4	1.7952	14.1488	0.8750	0.5570	1.1141	0.6445	1.2016
1 5/8	1.9333	13.1382	0.8125	0.5173	1.0345	0.5985	1.1158
1 1/2	2.0944	12.1276	0.7500	0.4775	0.9549	0.5525	1.0299
1 7/16	2.1855	11.6223	0.7187	0.4576	0.9151	0.5294	0.9870
1 3/8	2.2848	11.1169	0.6875	0.4377	0.8754	0.5064	0.9441
1 5/16	2.3936	10.6116	0.6562	0.4178	0.8356	0.4834	0.9012
1 1/4	2.5133	10.1062	0.6250	0.3979	0.7958	0.4604	0.8583
1 3/16	2.6456	9.6010	0.5937	0.3780	0.7560	0.4374	0.8154
1 1/8	2.7925	9.0958	0.5625	0.3581	0.7162	0.4143	0.7724
1 1/16	2.9568	8.5904	0.5312	0.3382	0.6764	0.3913	0.7295
1	3.1416	8.0851	0.5000	0.3183	0.6366	0.3683	0.6866
15/16	3.3510	7.5798	0.4687	0.2984	0.5968	0.3453	0.6437
7/8	3.5904	7.0744	0.4375	0.2785	0.5570	0.3223	0.6007
13/16	3.8666	6.5692	0.4062	0.2586	0.5173	0.2993	0.5579
3/4	4.1888	6.0639	0.3750	0.2387	0.4775	0.2762	0.5150
11/16	4.5696	5.5586	0.3437	0.2189	0.4377	0.2532	0.4720
2/3	4.7124	5.3903	0.3333	0.2122	0.4244	0.2455	0.4577
5/8	5.0265	5.0532	0.3125	0.1989	0.3979	0.2301	0.4291
9/16	5.5851	4.5479	0.2812	0.1790	0.3581	0.2071	0.3862
1/2	6.2832	4.0426	0.2500	0.1592	0.3183	0.1842	0.3433
7/16	7.1808	3.5373	0.2187	0.1393	0.2785	0.1611	0.3003
2/5	7.8540	3.2340	0.2000	0.1273	0.2546	0.1473	0.2746
3/8	8.3776	3.0319	0.1875	0.1194	0.2387	0.1381	0.2575
1/3	9.4248	2.6947	0.1666	0.1061	0.2122	0.1228	0.2289
5/16	10.0531	2.5266	0.1562	0.0995	0.1989	0.1151	0.2146
2/7	10.9956	2.3100	0.1429	0.0909	0.1819	0.1052	0.1962
1/4	12.5664	2.0213	0.1250	0.0796	0.1591	0.0921	0.1716
2/9	14.1372	1.7967	0.1111	0.0707	0.1415	0.0818	0.1526
1/5	15.7080	1.6170	0.1000	0.0637	0.1273	0.0737	0.1373
3/16	16.7552	1.5160	0.0937	0.0597	0.1194	0.0690	0.1287
1/6	18.8496	0.5053	0.0833	0.0531	0.1061	0.0614	0.1144

*NOTE: Dimensions listed are for HOB CUT TEETH ONLY. Shaper cut teeth may be slightly larger. Consult factory for exact measurement.

All Circular Pitch Gears Are Made-To-Order

Rules and Formulas
For Module (Metric) Spur Gear Calculations

(Module Represents the Amount of Pitch Diameter per Tooth)

To Find	Having	Rule	Formula
Metric Module (m)	Pitch Diameter (PD) and Number of Teeth (N)	Divide Pitch Diameter (PD) in millimeters (*mm*) by Number of Teeth (N)	$m = \frac{PD\ mm}{N}$
	Circular Pitch (DP) in millimeter	Divide Circular Pitch (DP) in millimeters (*mm*) by Pi (3.1416)	$m = \frac{CP\ mm}{3.1416}$
	Diametral Pitch (DP)	Divide 25.4 by Diametral Pitch (DP)	$m = \frac{25.4}{DP}$
	Outside Diameter (OD) and Number of Teeth (N)	Divide Outside Diameter (OD) in millimeters (*mm*) by Number of Teeth (N) plus 2	$m = \frac{OD}{N + 2}$
Pitch Diameter (PD)	Module (m) and Number of Teeth (N)	Multiply Module (m) by Number of Teeth (N)	$PD\ mm = m \times N$
	Number of Teeth (N) and Outside Diameter (OD)	Divide the product of Outside Diameter (OD) and Number of Teeth (N) by Number of Teeth (N) plus 2	$PD = \frac{OD \times N}{N + 2}$
	Outside Diameter (OD) and Module (m)	Multiply Module (m) by 2 and subtract from Outside Diameter (OD)	$PD = OD - (m \times 2)$
Outside Diameter (OD)	Module (m) and Number of Teeth (N)	Number of Teeth (N) plus 2 multiplied by Module (m)	$OD\ mm = (N + 2) \times m$
Diametral Pitch (DP)	Module (m)	Divide 25.4 by Module (m)	$DP = \frac{25.4}{m}$
Circular Pitch (DP)	Module (m)	Multiply Module (m) by Pi (3.1416)	$CP\ mm = m \times 3.1416$
Addendum (a)	Module (m)	Addendum (a) equals Module (m)	$a = m$
Whole Depth (ht)	Module (m)	Multiply 2.157 by Module (m)	$ht\ mm = 2.157 \times m$
Thickness of Tooth (t)	Module (m) and Outside Diameter (OD)	Multiply Pitch Diameter (PD) in millimeters (*mm*) by sine of angle of 90 divided by Number of Teeth (N)	$t\ mm = PD\ mm \times \text{Sine}\ \frac{90}{N}$
ANSI Module (m)	Pitch Diameter (PD) in inches and Number of Teeth (N)	Divide Pitch Diameter (PD) in inches by Number of Teeth (N)	$m'' = \frac{PD''}{N}$ (Answer in fraction)

Note: Rules and formulas relating to tooth depth and outside diameter apply to full-depth, equal addendum gears.

Module Pitch
Tooth Dimensions

Tooth Dimensions Based Upon Module System
(One millimeter equals 0.03937 inch)

Module (DIN Standard Series)	Equivalent Diametrical Pitch	Circular Pitch		Addendum (mm)	Dedendum * (mm)	Whole Depth * (mm)	Whole Depth ** (mm)
		Millimeters	Inches				
0.30	84.667	0.943	0.0371	0.30	0.350	0.650	0.647
0.40	63.500	1.257	0.0495	0.40	0.467	0.867	0.863
0.50	50.800	1.571	0.0618	0.50	0.583	1.083	1.079
0.60	42.333	1.885	0.0742	0.60	0.700	1.300	1.294
0.70	36.286	2.199	0.0865	0.70	0.817	1.517	1.510
0.80	31.750	2.513	0.0989	0.80	0.933	1.733	1.726
0.90	28.222	2.827	0.1113	0.90	1.050	1.950	1.941
1.00	25.400	3.142	0.1237	1.00	1.167	2.167	2.157
1.25	20.320	3.927	0.1546	1.25	1.458	2.708	2.697
1.50	16.933	4.712	0.1855	1.50	1.750	3.250	3.236
1.75	14.514	5.498	0.2164	1.75	2.042	3.792	3.774
2.00	12.700	6.283	0.2474	2.00	2.333	4.333	4.314
2.25	11.289	7.069	0.2783	2.25	2.625	4.875	4.853
2.50	10.160	7.854	0.3092	2.50	2.917	5.417	5.392
2.75	9.236	8.639	0.3401	2.75	3.208	5.958	5.932
3.00	8.466	9.425	0.3711	3.00	3.500	6.500	6.471
3.25	7.815	10.210	0.4020	3.25	3.791	7.041	7.010
3.50	7.257	10.996	0.4329	3.50	4.083	7.583	7.550
3.75	6.773	11.781	0.4638	3.75	4.375	8.125	8.089
4.00	6.350	12.566	0.4947	4.00	4.666	8.666	8.628
4.50	5.644	14.137	0.5566	4.50	5.250	9.750	9.707
5.00	5.080	15.708	0.6184	5.00	5.833	10.833	10.785
5.50	4.618	17.279	0.6803	5.50	6.416	11.916	11.864
6.00	4.233	18.850	0.7421	6.00	7.000	13.000	12.942
6.50	3.908	20.420	0.8035	6.50	7.583	14.083	14.021
7.00	3.628	21.991	0.8658	7.00	8.166	15.166	15.099
8.00	3.175	25.132	0.9895	8.00	9.333	17.333	17.256
9.00	2.822	28.274	1.1132	9.00	10.499	19.499	19.413
10.00	2.540	31.416	1.2368	10.00	11.666	21.666	21.571
11.00	2.309	34.558	1.3606	11.00	12.833	23.833	23.728
12.00	2.117	37.699	1.4843	12.00	14.000	26.000	25.884
13.00	1.954	40.841	1.6079	13.00	15.166	28.166	28.041
14.00	1.814	43.982	1.7317	14.00	16.332	30.332	30.198
15.00	1.693	47.124	1.8541	15.00	17.499	32.499	32.355
16.00	1.587	50.266	1.9790	16.00	18.666	34.666	34.512
18.00	1.411	56.549	2.2263	18.00	21.000	39.000	38.826
20.00	1.270	62.832	2.4737	20.00	23.332	43.332	43.142
22.00	1.155	69.115	2.7210	22.00	25.665	47.665	47.454
24.00	1.058	75.398	2.9685	24.00	28.000	52.000	51.768
27.00	0.941	84.823	3.339	27.00	31.498	58.498	58.239
30.00	0.847	94.248	3.711	30.00	35.000	65.000	64.713
33.00	0.770	103.673	4.082	33.00	38.498	71.498	71.181
36.00	0.706	113.097	4.453	36.00	41.998	77.998	77.652
39.00	0.651	122.522	4.824	39.00	45.497	84.497	84.123
42.00	0.605	131.947	5.195	42.00	48.997	90.997	90.594
45.00	0.564	141.372	5.566	45.00	52.497	97.497	97.065
50.00	0.508	157.080	6.184	50.00	58.330	108.330	107.855
55.00	0.462	172.788	6.803	55.00	64.163	119.163	118.635
60.00	0.423	188.496	7.421	60.00	69.996	129.996	129.426
65.00	0.391	204.204	8.040	65.00	75.829	140.829	140.205
70.00	0.363	219.911	8.658	70.00	81.662	151.662	150.997
75.00	0.339	235.619	9.276	75.00	87.495	162.495	161.775

* Dedendum and total depth when clearance = 0.1666 x module, or one-sixth module.

** Total Depth equivalent to American standard full-depth teeth. (Clearance = 0.157 x Module.).

Bevel & Miter Gear Formulas

To Find	Rule	Formula
Pitch Diameter (PD)	Divide Number of Teeth (N) by Diametral Pitch (DP)	$PD = \frac{N}{DP}$
Tangent of Pitch Angle (Pα) of Driven	Divide Number of Teeth (N) in Driven by Number of Teeth (N) in Driver	$\tan(P\alpha\ Driven) = \frac{N\ Driven}{N\ Driver} = Ratio$
Pitch Angle (Pα) of Driver	Subtract Pitch Angle (Pα) of Driven from 90°	$P\alpha\ \Gamma\ Driver = 90° - \alpha\ Driven$
Pitch Cone Radius (Pr)	Divide Pitch Diameter (PD) by Twice the Sine of Pitch Angle (Pα)	$Pr = \frac{PD}{2\sin(P\alpha)}$
Tangent of Addendum Angle (α)	Divide Addendum (a) by Pitch Cone Radius (Cr)	$\tan(\alpha) = \frac{a}{Cr}$
Face Angle (Fα)	Add Addendum Angle (α) to Pitch Angle (Pα)	$F\alpha = \alpha + P\alpha$
Tangent of Dedendum Angle (dα)	Divide Dedendum (d) by Pitch Cone Radius (Cr)	$\tan(d\alpha) = \frac{d}{Cr}$
Root Angle (Rα)	Subtract Dedendum Angle (dα) from Pitch Angle (Pα)	$R\alpha = P\alpha - d\alpha$
Angular Addendum (aΦ)	Multiply Addendum (a) by cosine of Pitch Angle (Pα)	$a\Phi = a \times \cos(P\alpha)$
Outside Diameter (OD)	Add 2 Angular Addendum (aΦ) to Pitch Diameter (PD)	$OD = 2\ a\Phi \times PD$
Mounting Distance (MD)	Add one-half the Pitch Diameter of Mating (PDg) plus Backing to Pitch Line (BL)	$MD = \frac{PDg}{2} + BL$
Distance From Cone Center to Crown (Cc)	Multiply one-half Outside Diameter (OD) by cotangent of Face Angle (Fα)	$Cc = \frac{OD}{2} \times \cot(F\alpha)$
Backing to Crown (Bc)	Subtract Cone Center to Crown (Cc) from Mounting Distance (MD)	$Bc = MD - Cc$
Ratio	Divide Number of Teeth (N) in Driven by Number of Teeth (N) in Driver	$Ratio = \frac{N\ Driven}{N\ Driver}$

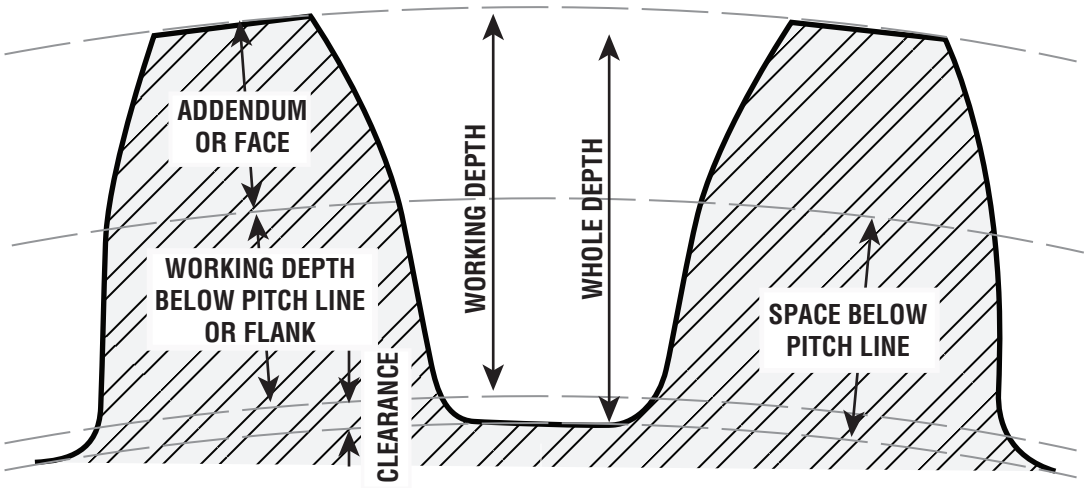
Formula For Worm Gears

(Based on Diametral Pitch)

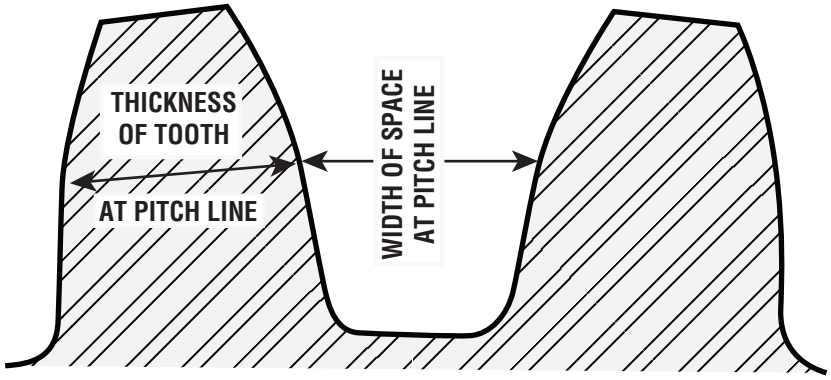
To Find	Rule	Formula
Worm Gear Pitch Diameter (PDg)	Divide Number of Teeth(N) by Diametral Pitch (DP)	$PDg = \frac{N}{DP}$
Worm Gear Throat Diameter (TDg)	Add 2 Addendum (a) to Pitch Diameter (PD)	TDg = 2 a + PD
Worm Gear Outside Diameter (ODg)	Add 3 Addendum (a) to Pitch Diameter (PD)	ODg = 3 a + PD
Worm Pitch Diameter (PDw)	Subtract the Worm Gear Pitch Diameter (PDg) from twice the Center Distance (CD)	PDw = 2 CD - PDg
Worm Outside Diameter (ODw)	Add 2 Addendum (a) to Worm Pitch Diameter (PDw)	ODw = PDw + 2 a
Worm Lead (Lw)	Divide 3.1416 by Diametral Pitch (DP) and multiply by Number of Threads (NT) in Worm	$Lw = \frac{3.1416}{DP} \times NT$
Cotangent of Worm Helix Angle (Hα)	Multiply Worm Pitch Diameter (PDw) by Diametral Pitch (DP) and divide by Number of Worm Threads (T)	$\cot(H\alpha) = \frac{PDw \times DP}{T}$
Center Distance (CD)	Add Worm Pitch Diameter to Worm Gear Pitch Diameter and divide sum by 2	$CD = \frac{PDw + PDg}{2}$
Ratio	Divide Number of Teeth in Worm Gear (N) by Number of Worm Threads (T)	$Ratio = \frac{N}{T}$

NOTE: Tooth data (Addendum, Full Depth, Etc.) is same as for spur gears.

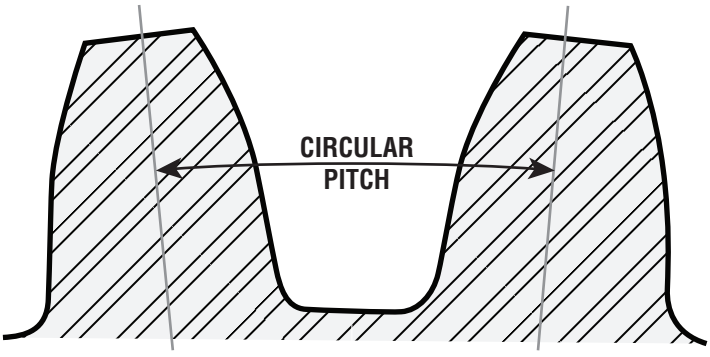
Comparative Sizes of Involute Gear Teeth



1 Diametral Pitch
3.1416" Circular Pitch



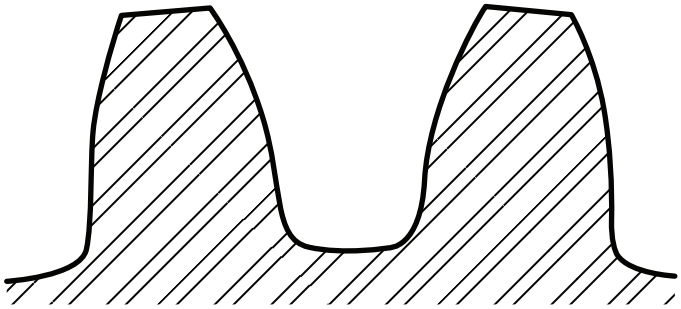
1 1/4 Diametral Pitch
2.5133" Circular Pitch



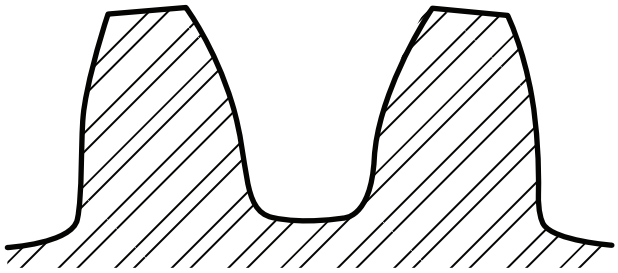
1 1/2 Diametral Pitch
2.0944" Circular Pitch

Formula For Worm Gears

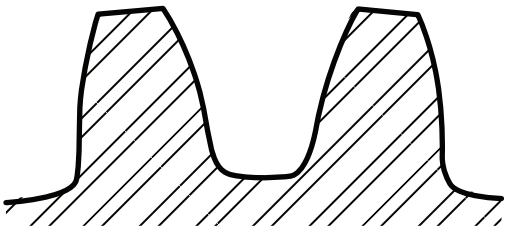
Comparative Sizes of Involute Gear Teeth



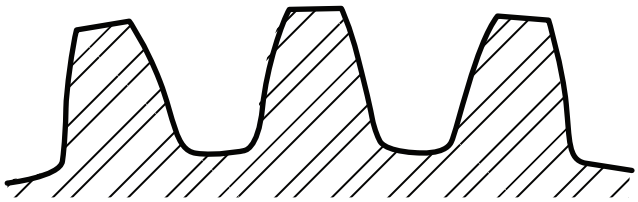
1 3/4 Diametral Pitch
1.7952" Circular Pitch



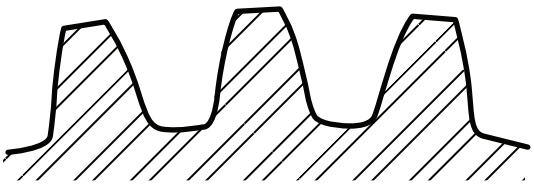
2 Diametral Pitch
1.5708" Circular Pitch



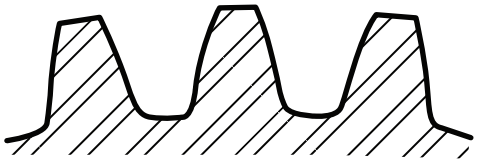
2 1/2 Diametral Pitch
1.2566" Circular Pitch



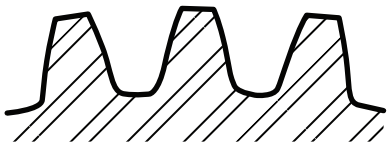
3 Diametral Pitch
1.0472" Circular Pitch



3 1/2 Diametral Pitch
.8976" Circular Pitch



4 Diametral Pitch
.7854" Circular Pitch



5 Diametral Pitch
.6283" Circular Pitch

6 Diametral Pitch
.5236" Circular Pitch

Comparative Sizes of Involute Gear Teeth

7 Diametral Pitch
.4488" Circular Pitch

8 Diametral Pitch
.3927" Circular Pitch

10 Diametral Pitch
.3142" Circular Pitch

12 Diametral Pitch
.2618" Circular Pitch

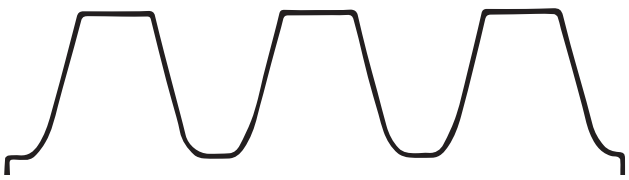
14 Diametral Pitch
.2244" Circular Pitch

16 Diametral Pitch
.1963" Circular Pitch

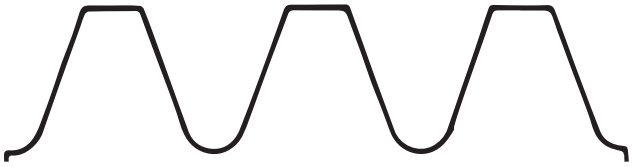
18 Diametral Pitch
.1745" Circular Pitch

20 Diametral Pitch
.1571" Circular Pitch

Gear Rack Comparison — 14½° and 20°

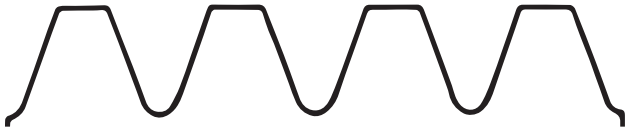


3 DP — 14½°



3 DP — 20°

4 DP — 14½°



4 DP — 20°

5 DP — 14½°

5 DP — 20°

6 DP — 14½°

6 DP — 20°

Formula For Worm Gears

Stock Steel Gears

Martin steel gears are manufactured from high quality carbon steel material. This material is used for strength and good hardening characteristics. These gears may be hardened by any method acceptable to good practice such as flame or induction hardening. Flame hardening is preferred so that only the teeth are hardened. Distortion is virtually eliminated and the bore is left soft for subsequent work.

Cast Gears

Martin cast iron gears are manufactured from high quality close grained controlled specification irons.

Reboring of Stock Gears

Most of Martin's Stock Gears may be rebored. The maximum recommended bore size is given for each gear. In reboring gears, care must be taken to hold the bore concentric with the pitch diameter. In most cases this would require a great amount of time. To cut costly set-up time when reboring, Martin holds the outside diameter of its gears concentric with the bore which in turn is concentric with the pitch diameter. The outside diameter is held to a closer total indicator reading than the pitch diameter. In the finer pitches, care should be taken not to distort the outside diameter when chucking.

Martin's steel gears are machined all over.

Rebore or rework may be accomplished by chucking on the hub. Concentricity must be controlled in order for gears to run at maximum efficiency.